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Clay Minerals Determination Methods and Neural Networks Application to Determine the Distribution of Clay Minerals in Kangan-4b Formations of Wells A and B

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ABSTRACT

Determination ofclay minerals for reservoir characterization in hydrocarbon formationsis very important. In this study, X-Ray diffraction test, type and percentage of clay minerals for two wells (Kangan-4b from well A) and (Kangan-4b well B) were determined and compared with cross plots. Finally, a new method to estimate the percentage of clay minerals through back-propagation neural network is presented in Kangan Formation. A network with two hidden layers based on test data and location coordinates of the X-Ray diffraction was used to train the software. The results show that the linear transfer function as a function of each hidden layer is optimized for the best algorithm in this study were diagnosed with LM algorithm. Network design has the ability to predict clay minerals in two wells.

Keywords: Cross plot, Artificial Neural Network, Clay Mineral, X-Ray Diffraction, Kangan Formation.

1. INTRODUCTION

Determination of clay minerals especially montmorillonite, because of the difficulty in improving their assessment of the amount of

oil exploitation, is more effective. Petrophysical cross plot, Scanning *Electron Microscope (SEM)*, X-Ray Diffraction (XRD) experiments are including the method of determining the percentage and type of clay minerals[1]. In some formations, the test results of XRD and cross plot are different. Neural network technique shows better results in predicting reservoir parameters[2]. This study compares the results obtained from XRD techniques and cross plot, the ANN method for the determination of clay minerals in non-core locations were used. Location and depth coordinates (XYZ) as input and the output of the network is the percentage of clay minerals[2,3]. Finally distributions of clay minerals were determined for both formations.

2. XRD

This method is useful technique for the detection and analysis of materials fines such as clay minerals. By using this method, we investigated the space between the layers of clay particles. Using XRD to examine the clay minerals is based on the clay particles were treated with radiation to penetrate the clay layer, network atomic and ionic slips by every single individual will fail. Before testing, the samples must be prepared. Sample preparation contain Sample No. 200 sieve, treated with acetic acid to remove carbonate, hydrogen peroxide 3% of Chile's example of washing to remove organic material, silt and clay separation by gravity method, three thin sections prepared dry heat and saturated ethylene glycol is separately[5].

3. ARTIFICIAL NEURAL NETWORK (ANN)

Artificial neural network is a processing technique that is inspired by studies on the brain and nervous system. In other words, these methods are mathematical models of biological neural structures. Each neural network usually involves a series of processing elements or neurons in the layers. Feedback network includes at least three layers, input, hidden and output. Each layer has a number of neurons. Hidden layer between the input and output layers can be more than one, which depends on the type of application. Neurons between layers by the numbers called weight are related. The number of neurons in each layer and the weights by determining the optimizing and detecting error is achieved. Neural network is aimed at determining optimal weights to obtain the best value for the output neurons. Back propagation network, is a common method of teaching Artificial Neural Network and learning how to be selected a certain goal. This net is a supervised learning method. In other words, the network is a set of training data needed to obtain the desired output for each input. Network; calculate the difference between the calculated output and the desired output. Error is emitted backwards in the network and the weights are adjusted during iterations (Fig.1)[4].

4. DISCUSSION

4.1 Sample 1 ofKanganFormation-4b in well A:

This sample is in depth of 3346 meters of well A and according to the Geological Survey this sample has been made up of dolomite and shale. Table 1 shows the percentage of clay minerals of this sample that was obtained from XRD experiments. Fig.1 and 2 respectively show

potassium versus PEF and thorium versus potassium cross plots. Each rectangle represents a type of clay minerals. The green areas are also relevant samples. Figure 3 shows the ratio of thorium to potassium versus PEF cross plot.

According to Table1, chlorite as the dominant mineral that identified by XRD, while potassium versus PEF cross plot does not show any information about clay minerals (Fig.1). In thorium versus potassium cross plot, illite and montmorillonite are dominant clay minerals (Fig. 2). Also thorium to potassium ratio versus PEF Cross plot illite as the dominant mineral shows (Fig. 3). Proposed a graph to determine the dominant clay mineral is Thorium versus potassium cross plot based on the data in Serra Table are done in Geolog software has been designed (Fig. 4). This graph shows that the chlorite is predominant mineral.

4.2 Sample 2 of Kangan Formation-4b in well B:

This sample is in depth of 3366meters of well B and according to the Geological Survey this sample has been made up of dolomite and shale. In Table 2, the percentage of clay minerals of this sample was obtained using XRD experiments. Figs 5, 6 and 7 respectively show potassium versus PEF cross plot, thorium versus potassium cross plot and thorium to potassium ratio versus PEF cross plot. Each of the rectangles represents a type of clay minerals. The green areas are also relevant samples.

According to Table 2, chlorite as the dominant minerals identified by XRD, while potassium versus PEF cross plot does not show any information about clay minerals and thorium versus potassium cross plot shows that the illite and montmorillonite as the dominant clay minerals (Fig.5 and 6). Also Thorium to potassium ratio versus PEF cross plot showed illite as the dominant mineral (Fig.7). The proposed chart to determine the dominant clay mineral is Thorium versus Potassium cross plot based on Serra mineralogy table is set in the Geolog software are done (Fig.8). This cross plot shows that the chlorite is dominant mineral.

4.3 NeuralNetwork Model:

In this study, best back propagation neural network designed and include samples 1,2 and 3 with the LM algorithms. Optimal network has a hidden layer transfer function is linear and the number of neurons of the hidden layer neurons is 20 (Table. 3). Best performance of the network in Fig. 9, as a graph of root mean square error for the training, validation and testing by software Matlab is depicted. Root mean square error of Validation data is 0.3 and the root mean square error of training datais17-10 × 8. Percentage of clay minerals in sample A Kangan Formation (wells that the percentage of clay minerals in them is not known) can be predicted by the optimized network. Table 4 shows distribution of clay minerals in wells 5, 7, 8, 3, 1, 2 and 6 of formation. According to their geographical. Black amounts are XRD data which have been obtained from core data. Blue data is estimated by the network and corrected data are shown green, so that total percentage of clay minerals in each well is100. Also percentage of clay minerals in sample 2 of Kangan (wells that percentage of clay

minerals in them is not known) can be predicted by the optimized network. Table 5 show distributions of clay minerals in wells 5, 7, 8, 3, 1, 2 and 6 in formation B respectively by their geography.

5. RESULTS

1- In Kangan 4-b (well A), according to XRD experiment, chlorite was known as the dominant clay mineral. Potassium versus PEF Cross plot does not show any information about clay minerals. Thorium versus potassium Cross plot show that the illite and montmorillonite as the dominant clay minerals. Also in Thorium to Potassium Ratio versus PEF cross plot, illite as the dominant clay mineral and thorium versus potassium cross plot that based on Serra mineralogy table show that the chlorite is predominate mineral and the results of this crossplot are agreement with the results of XRD.

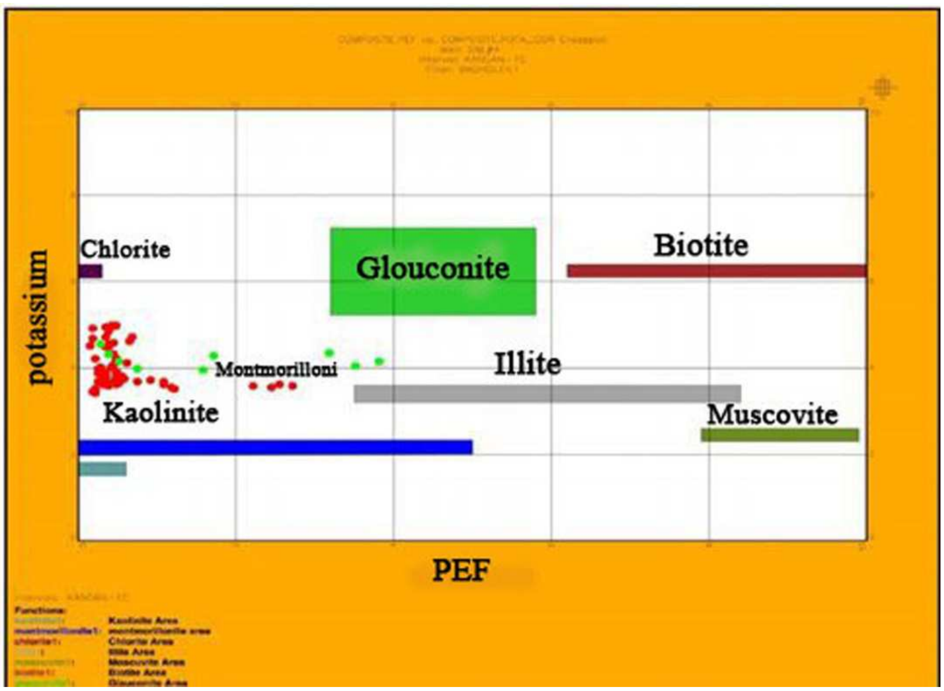

Figure 1:Potassium versus PEF cross plot of Kangan-4b in well A formation[6]

2- Dominant clay mineral in Kangan 4-b (well B), that obtained from XR Dexperiments is chlorite, while potassium versus PEF crossplot does not show any information about clay minerals and in thorium versus potassium crossplot, illite and montmorillonite are dominant clay minerals. Also thorium to potassium ratio versus PEF crossplot indicated that illite is dominant claymineral. In formation 2, thorium versus potassium crossplot based on Serra mineralogy table was designed by Geolog software. This crossplot showed that the dominant clay mineral is chlorite that

obtained from XRD results and in agreement with the results of other crossplot.

3- Aback-propagation neural network was designed to prediction the percentage of clay minerals in places that are not clear. Optimal network has the LM algorithm with a hidden layer of 20 neurons with normalizing data and linear transfer function for each two layers.

4- The distribution of clay minerals by the extended network of other wells in Kangan 4-b (well A), indicates that the dominant minerals (chlorite) from well B to well A increases, while problematic mineral (Montmorillonite) fromwell A to well B increases.

5- The distribution of clay minerals by the extended network of other wells in Kangan 4-b (well B), indicates that the dominant minerals (chlorite) in well A is 80 percent (the highest value) and well B it amounts decreases to 62.71 percent, while problematic mineral (Montmorillonite) in well B has the highest value(8.14%) and to the well A decreases to 2.22 percent.

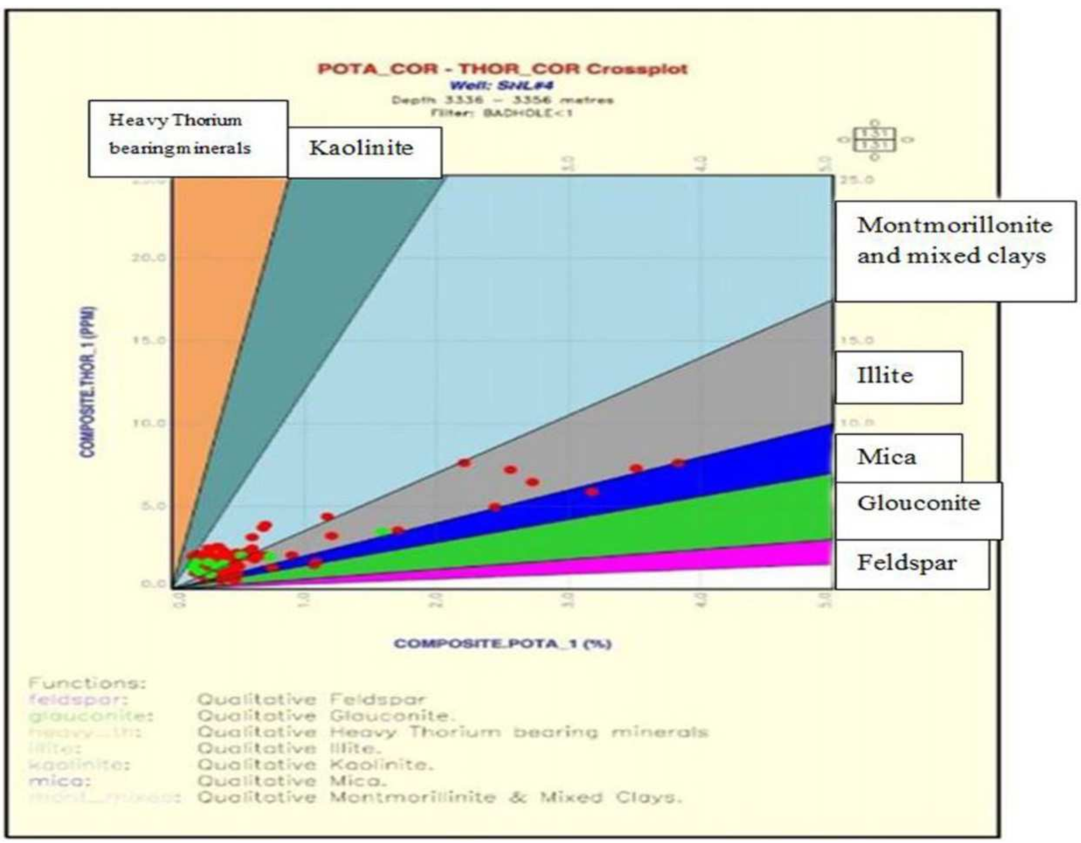

Figure 2: Thorium versus Potassium cross plot of Kangan-4b in well A formation [6]

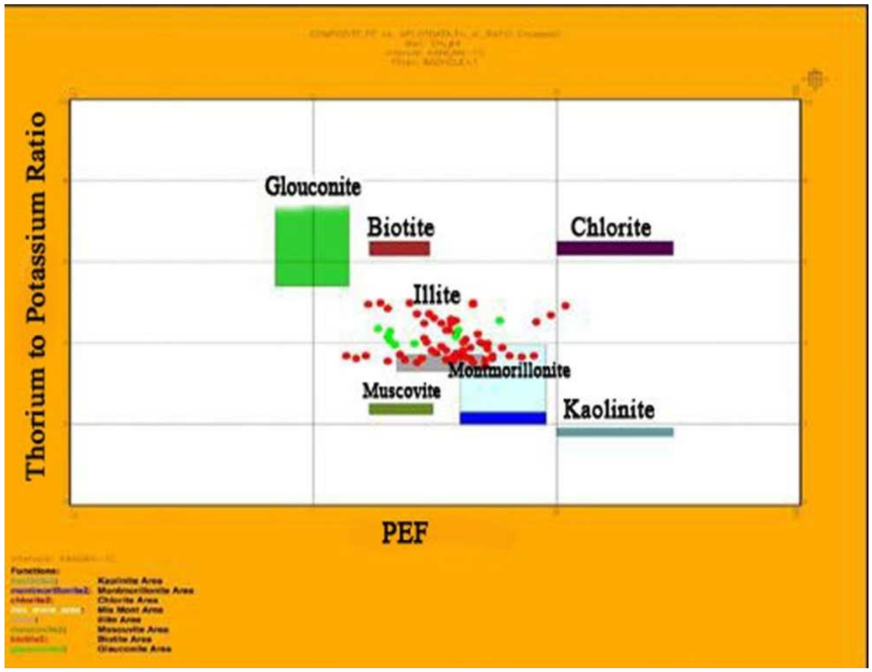

Figure 3: Thorium to Potassium Ratio versus PEF Cross plot of Kangan-4b in well A formation [6]

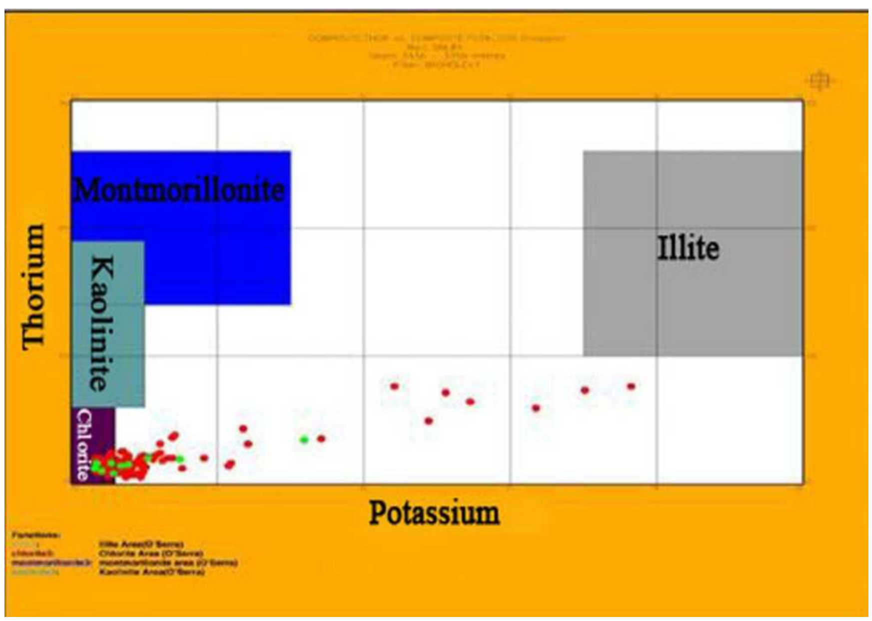

Figure 4: Thorium versus Potassium (Serra) Cross plot of Kangan-4b in well A formation [6]

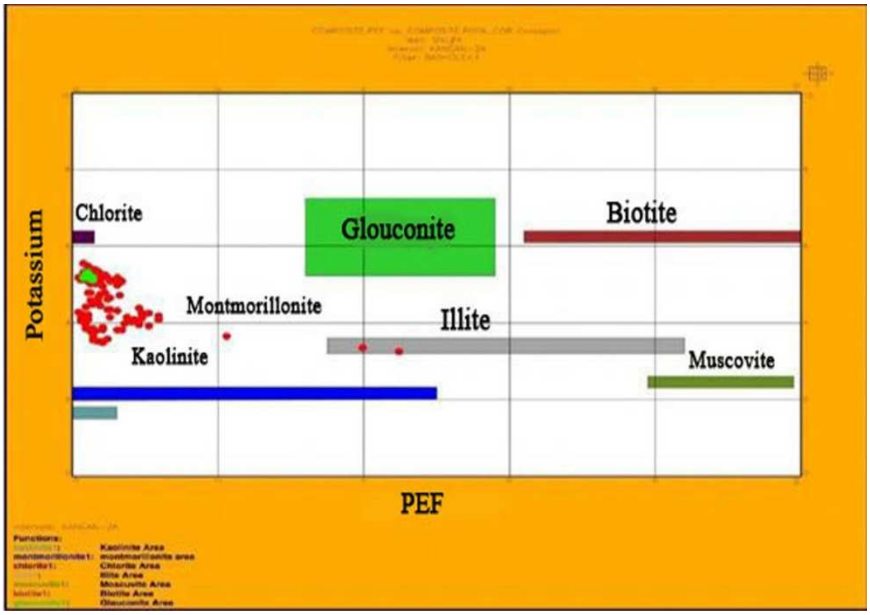

Figure 5: Potassium versus PEF cross plot in well B formation [6]

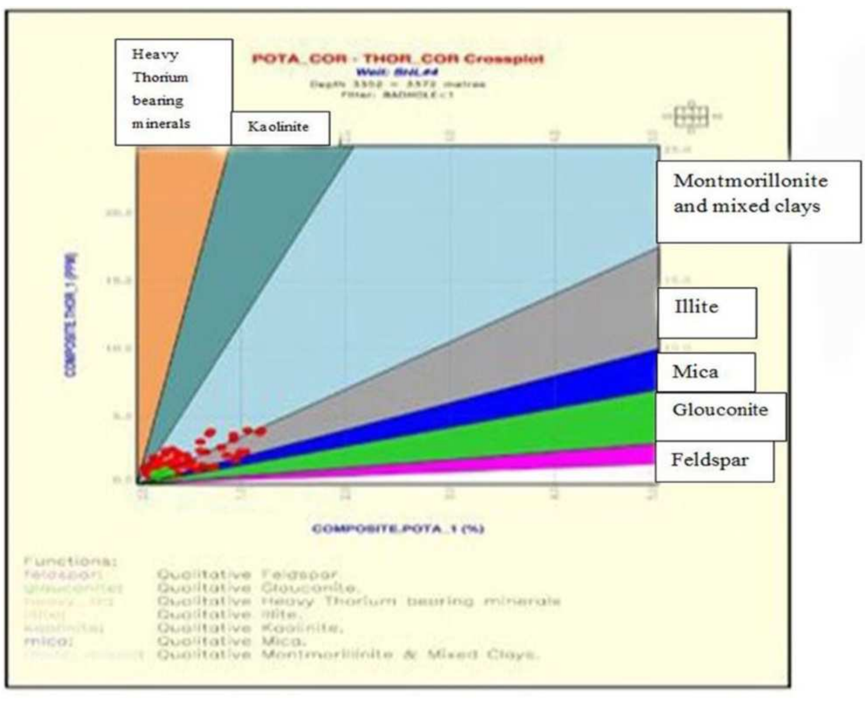

Figure 6: Thorium versus Potassium Cross plot in well B formation [6]

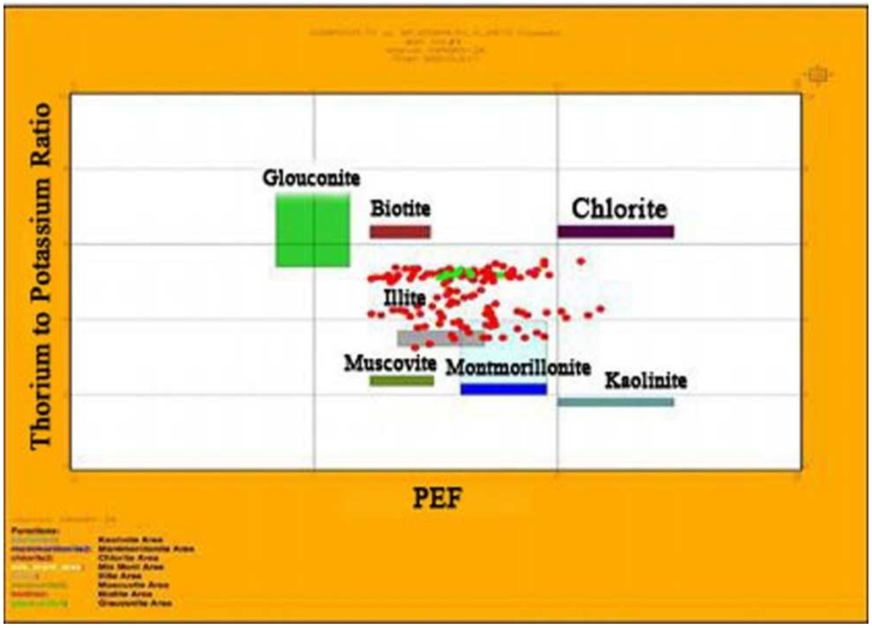

Figure 7:Thorium to Potassium Ratio versus PEF Cross plot in well B formation [6]

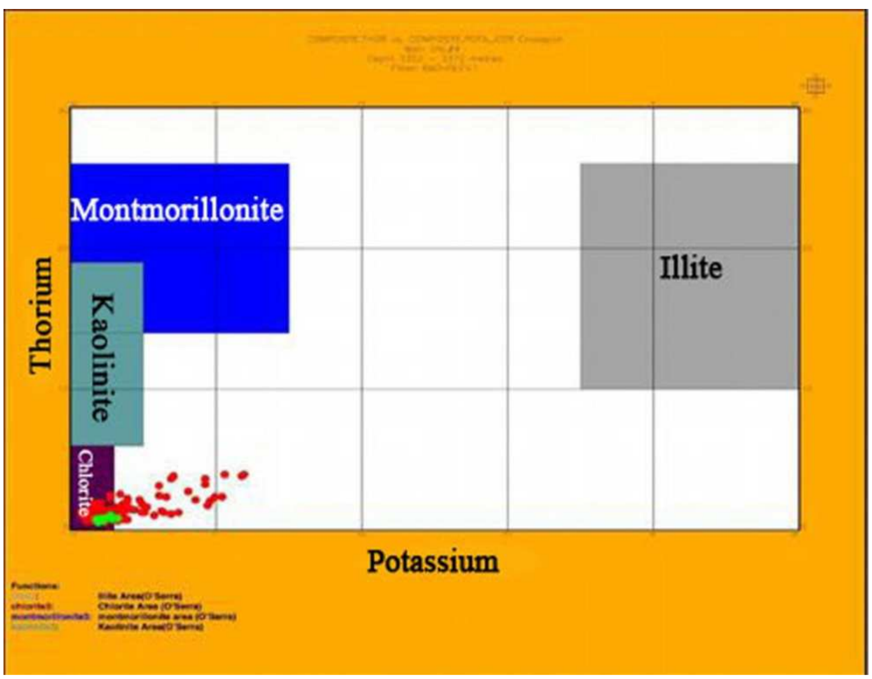

Figure 8:Thorium versus Potassium (Serra) Cross plot in well B formation [6]

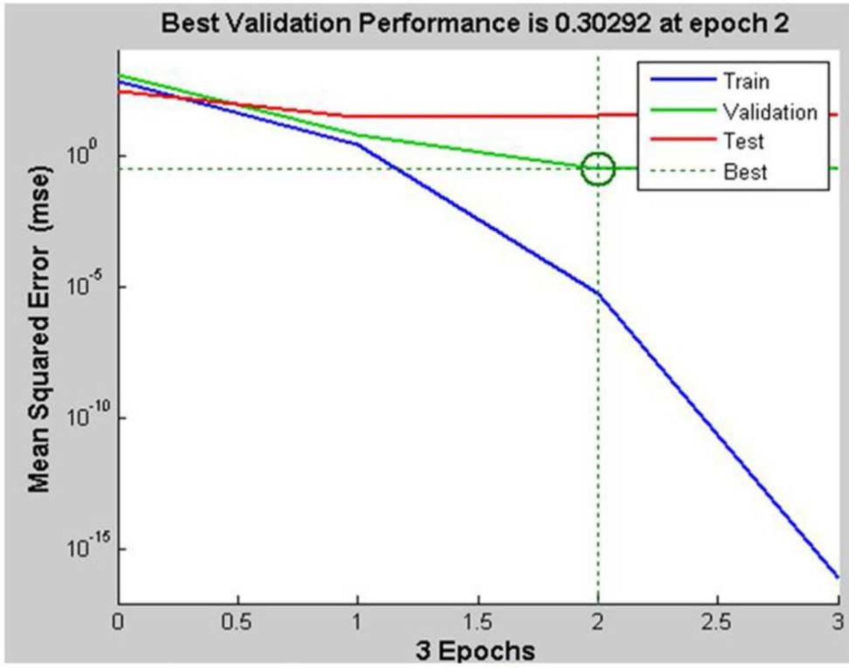

Figure 9: Best performance of training, validation and testing

Table 1: percentage of clay minerals of Kangan-4b in well A formation

Clay Minerals	Percentage
Chlorite	80
Illite	11
Kaolinite	6.66
Montmorillonite	2.22

Table.3:network performance on transfer function type and number of hidden layer, Kangan Formation, well A.

Performance function oftraining	Performance functionof Validation	The secondtransfer function	The firsttransfer function	The number ofneurons inthe second layer	Number ofneurons inthe first layer	Algorithm
$4.55*10^{-14}$	79.19	-	Purelin	-	20	LM
$8*10^{-17}$	0.3029	-	Purelin	-	20	LM
$1.62*10^{-16}$	1.91	Purelin	Purelin	10	20	LM

Table.4:Distribution of clay minerals in Kangan Formation (well A)

Formation 1, Kangan 4b of well A Clay minerals (percentage)	**5**	**7**	**8**	**3**	**1**	**2**	**6**
Chlorite	78.26	79.159	77.014	73.791	71.179	66.565	62.43
Illite	14.49	14.871	16.324	16.936	17.704	19.032	20.47
Kaolinite	5.80	6.258	7.172	8.019	8.796	10.161	13.47
Montmorillonite	1.45	0.413	0.737	2.119	3.084	4.804	3.63
Total	100	100.70	101.25	100.86	100.76	100.56	100
Modified Chlorite	78.26	78.607	76.065	73.158	70.64	66.193	62.43
Modified Illite	14.49	14.768	16.123	16.790	17.569	18.926	20.47
Modified Kaolinite	5.80	6.214	7.083	7.950	8.729	10.104	13.47
Modified Kaolinite	1.45	0.410	0.728	2.101	3.060	4.777	3.63

Table.5:Distribution ofclay mineralsin Kangan Formation (well B)

Formation 1, Kangan, 4b of well B Clay minerals (percentage)	**5**	**7**	**8**	**3**	**1**	**2**	**6**
Chlorite	80.00	78.343	75.475	72.95	70.759	66.746	62.71
Illite	11.11	11.634	13.440	13.78	14.923	16.411	17.11
Kaolinite	6.66	6.766	7.779	8.45	10.307	12.327	12.03
Montmorillonite	2.22	2.968	4.045	4.82	5.407	6.628	8.14
Total	99.99	99.955	99.012	100	101.39	102.11	99.99
Modified Chlorite	80.00	78.569	74.921	72.95	69.785	65.365	62.71
Modified Illite	11.11	11.668	13.341	13.78	14.717	16.072	17.11
Modified Kaolinite	6.66	6.786	7.721	8.45	10.165	12.072	12.03
Modified Kaolinite	2.22	2.977	4.015	4.82	5.332	6.491	8.14

6. CONCLUSIONS

1- It is suggested that neural network methods for other formations tested and the distribution of clay minerals in these formations be drawn.

2- From other artificial intelligence techniques such as fuzzy logic and genetic algorithm can be used to improve neural network.

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